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Comparative Analysis of Helical Compression Spring and Carbon/ Epoxy Composite Spring used in Damper by Using FEA

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ABSTRACT

The automobile trade has shown magnified interest within the replacement of ferrous metals using composite materials because of high strength to weight ratio. The study represents new approach to design helical compression spring by using workbench. The composite materials used are E-glass/Epoxy or Carbon fiber/Epoxy. Spring analysis is completed with FEA and results are compared with steel spring. The study shows that the weight reduction achieved with composite spring. Thus, indicating that the composite material springs may be effectively used as replacement for heavy steel springs. during this study, the most investigation of the study is to reduce the weight of product whereas upholding its strength. Then to unravel problem during this regard composite materials are play a very important role. Relationship among design parameters and compressive stress has been obtained. during this analysis it's observed that coil diameter will increase stress on the spring decreases and glass fiber epoxy shows the most spring rate.

Keywords: Helical Spring, FEA Analysis, Conventional Materials, Composite Material, Stresses.

1. Introduction

According to A.M. Whal: "A mechanical spring may be defined as an elastic body whose primary function is to deflect or distort under load (or to absorb energy) and which regains its original shape when released after being distorted". He classifies the main functions of springs as one of four things: to absorb shock, to apply force, to support a structure and to provide load control [5]. Springs have widely different properties and functions, and so cannot be all analyzed with the same techniques, so as the purpose of this dissertation, we will consider only helical compression spring shown in fig. 1.1. These springs are by far the most common type and are useful in the operation of many devices due to several desirable properties, such as a near linear rate (particularly after the first 20% of deflection), different materials that can be used to make them, and the ease of manufacture. For this reason, helical compression springs have been in use for some time [5].

1.1 Objectives of The Project Work

1) To identify the best suited analysis for compression spring for the given application.

2) To identify various influences to which the spring is subjected to during its operation that may be detrimental to its life.

3) To determine such critical parameters or the factors that needs further study.

4) To analyze the spring using FEA techniques/ practically.

5) To recommend improvements in the areas of design/ Material/ Process for enhancing the life of the spring

Design of Helical Compression Spring

For particular application many number of springs can be designed by changing the parameter i.e. mean coil diameter (D), wire diameter (d) and number of active turns. Thus design is done with trial and error method by varying the above parameters to get the final design with same results as that of reference steel sprig. The parameters were selected by inserting various values od d, D and N in the following equation.

2.1 For Steel spring:

Considered Force (P) = 1000 N for design purpose, Solid Height (Ls) = 225 mm Wire diameter (d) = 7.5 mm, Mean diameter (D) = 42.5 mm, Sut = 1000 N/mm 2 , Turns (n) = 17

Spring index (C) = $\frac{D}{d}=\frac{42.5}{7.5}$=5.66

The permissible stress is given by,

τ=0.5 Sut = 0.5 (1000) = 500 N/mm^2

$K=\frac{4C-1}{4C-4}+(\frac{0.615}{C})=\frac{4*5.66-1}{4*5.66-4}+(\frac{0.615}{5.66})$= 1.26960145

$\tau=K\,\frac{8*P*D}{\pi*d^3}$=1.269($\frac{8*1000*42.5}{\pi*7.5^3}$)= 461.920 N/mm²

Deflection

$\delta=\frac{8*P*D^3*N}{Gd^4}=\frac{8*1000*42.5^3*17}{87500*7.5^4}$=37.70965785 mm

Stiffness=$\frac{load}{deflection}=\frac{1000}{37.709}$=26.51841 N/mm

2.2 For carbon/Epoxy

Spring Index (C)=4.5 , Wire Diameter (d)=15 mm , Mean Diameter (D)=67.5 mm , Number of Active turns (N)=3 Now

Deflection

$\delta=\frac{8*P*D^3*N}{Gd^4}=\frac{8*1000*67.5^3*3}{3900*15^4}$=37.38 mm

Shear Stress

$\tau=K\,\frac{8*P*D}{\pi*d^3}$=1.269($\frac{8*1000*67.5}{\pi*15^3}$)= 68.83 N/mm²

The design is safe as design stress is lower than permissible and the deflection results are satisfactory for the application Thus, this design is selected.

Finite Element Analysis

Static analysis

The linear static analysis is carried out to determine the total deformation and shear stress. The deformation and stress analysis is carried for each 500N, 750N and 1000N load. The results are recorded accordingly. The results are within the permissible limit which indicated that the design is safe. The 1000N results are represented here.

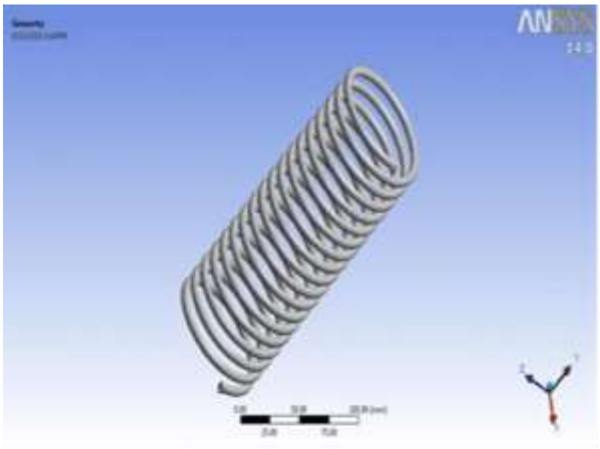

Fig. 3.1 Spring Geometry model in Ansys

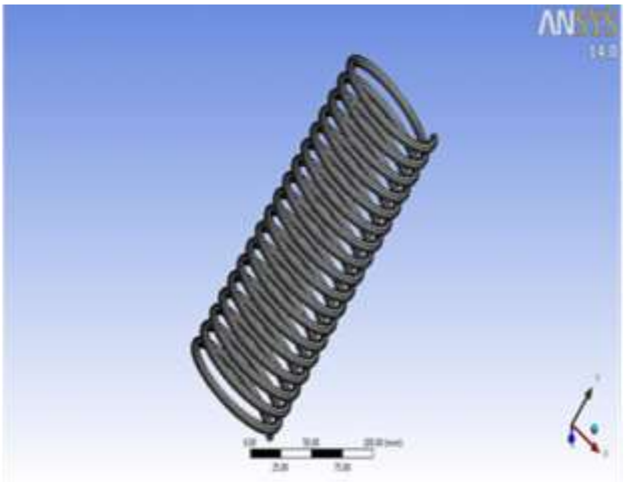

Fig. 3.2 Geometry Hex Meshing

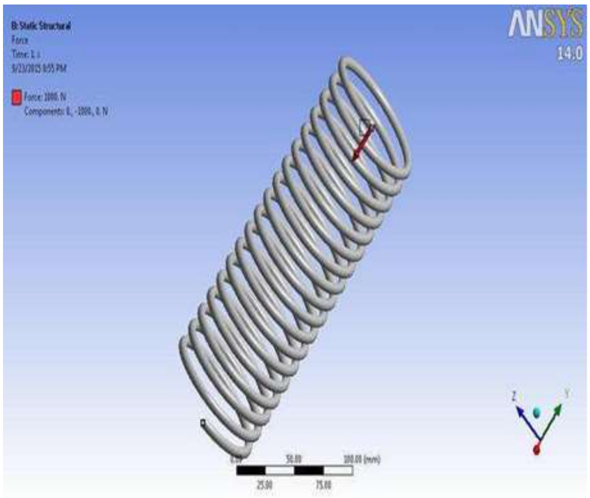

Fig .3.3 Load applied on spring

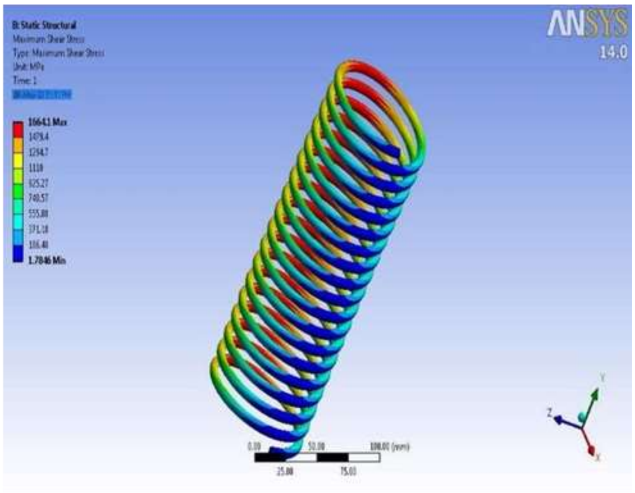

Fig 3.4 Load applied on spring

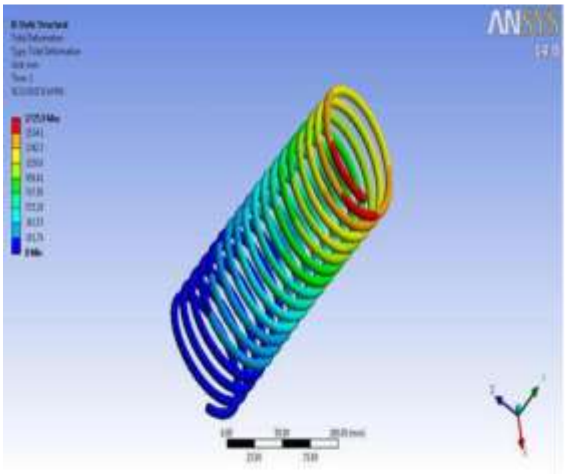

Fig.3.5 Maximum shear stress

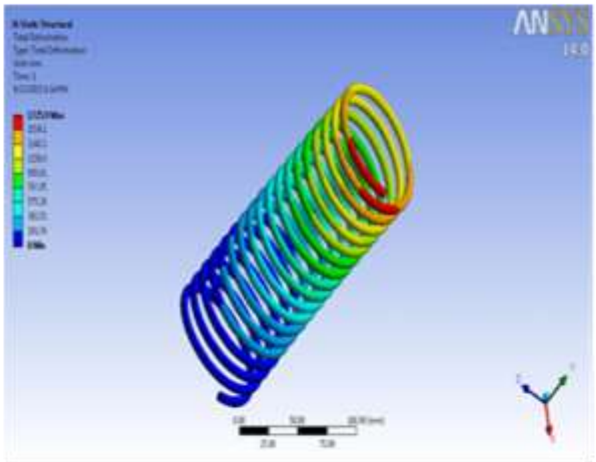

Fig.3.6 Von-Mises stress

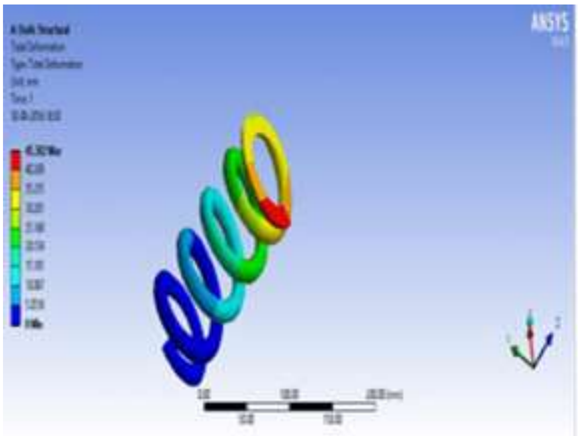

Fig.3.7 Deflection of Carbon/Epoxy spring for 1000N

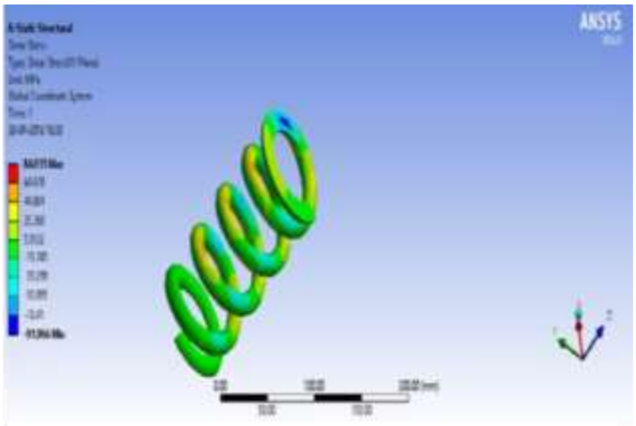

Fig.3.8 Shear stress of Carbon/Epoxy spring for 1000N

Table 3.1 Variation of maximum shear stress on stainless steel and maximum shear stress in Ansys on e-glass/Epoxy with load

Load(N)	Theoretical Maxi. Shear Stress(N/mm2)	Ansys Maxi. Shear Stress (N/mm2)
500	230.929	285.210
1000	461.920	498.120

1500	692.788	742.210
2000	923.832	958.920
3000	1315.76	1380.01
3500	1489.68	1509.99

As shown in the above table of Load Vs maximum shear stress ,In the ansys and Theoretical analysis has been carried out . From the analysis it is obtained that the stress acting on Theoretical are less than the Ansys at same loading condition.

Table 3.2 Variation of maximum shear stress theoretically and maximum shear stress analytically with load

Load(N)	Maximum Shear Stress for stainless steel (N/mm^2)	Maximum Shear Stress for Epoxy(N/mm^2)
500	285.210	241.929
1000	498.120	462.920
1500	742.210	688.788
2000	958.920	911.801
3000	1310.01	1285.76
3500	1809.99	1784.68

Result and Discussion

Table 4.1 Theoretical Deflection

Load In N	Deflection in mm	
	Steel	Carbon/Epoxy
500	18.78	18.69
750	28.18	28.03
1000	37.17	37.38

Table 4.2 FEA Deflection

Load In N	Deflection in mm	
	Steel	Carbon/Epoxy
500	22.673	22.651
750	34.009	33.976
1000	45.34	45.302

Table 4.3 Weight Results

Steel (Average)	Carbon/Epoxy (Average)
900 grams	236 grams

The weight of composite spring is very small as compared of steel spring. carbon/Epoxy spring with 236 gram is almost 70% lighter.

4.1 Spring Parameter Result

a) Coil diameter Vs Compressive stress:-

Figure shows relationship between coil diameter Vs compressive stress has been obtained. In this fig showing that when mean diameter of spring increases compressive stress also goes on increasing upto 27 mm. There compressive stress decreases because stress exceeds elastic limit.

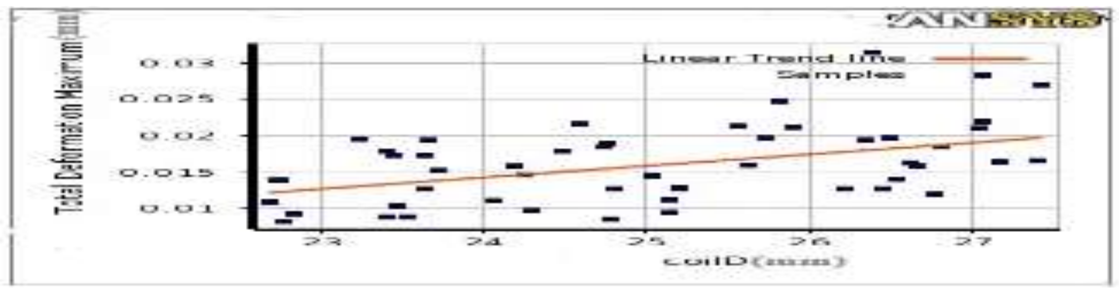

Fig .4.1. Mean diameter Vs Compressive stress

c) Wire diameter Vs Compressive stress:-

Figure shows the wire diameter Vs compressive stress. when wire diameter of spring is increases compressive stress decreases up to 5mm after these compressive stress increase force is transferred in helical direction to another end of spring. From fig. it is observed that 5mm is optimum wire diameter where compressive stress is 4.8N/mm2.

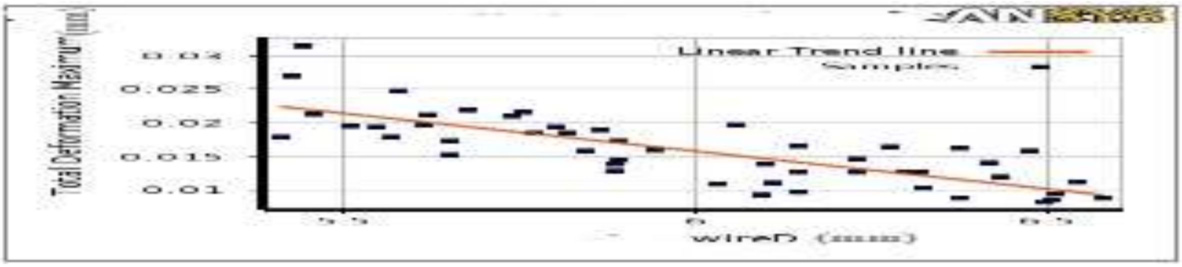

Fig. 4.2. Wire diameter Vs Compressive stress

d) Force Vs Compressive stress

Figure shows graph of force Vs compressive stress. In this graph shown that when force increases compressive stress also increase, so compressive stress depend on applied force. From obtained regression model it is observed that force is one among significant parameter.

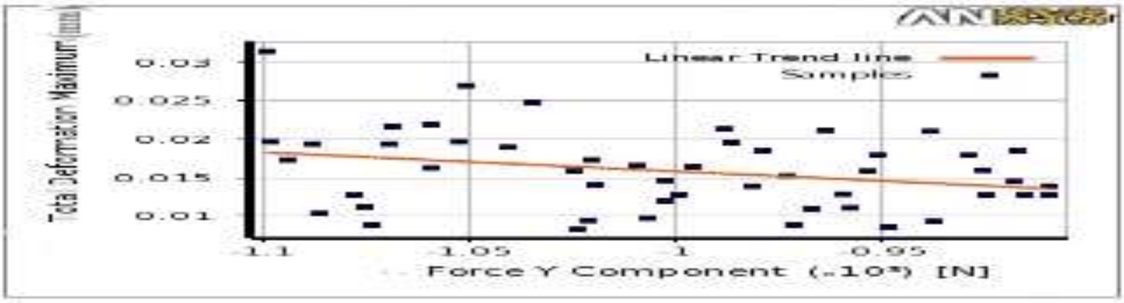

Fig. 4.3 Force Vs Compressive stress

Conclusion

To get comfortable suspension in two wheeler it is necessary to be analyzed in context of the maximum safe load of a helical compression spring and find out the maximum stresses acting on helical compression spring. The original material of Stainless steel (AISI 304 / ASTM A 313)) is replaced by e-glass /Epoxy or Carbon/Epoxy material. The original material of helical compression spring acting maximum stresses than Epoxy. From analytical and FEA results it has been found that steel helical springs can be replaced with combination of conventional steel and composite material helical spring with stiffness remaining same. The composite helical springs can be effectively used in automobiles without affecting the performance of the suspension system of the vehicles. They provide around 50-70 % weight reduction as compared to steel spring.

The conclusions drawn from the theoretical and FEA analysis carried out are as follows:

- In the present work, helical compression spring is modeled and static analysis is carried out ANSYS software.
- It is observed that the maximum stress is developed at the inner side of the spring coil ANSYS.
- The allowable design stress is found between the corresponding loads 500 to 1500 N.

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